# MILITARY IMPLICATIONS OF SEASONAL ENVIRONMENTAL CHANGE AS REVEALED THROUGH TIME-LAPSE PHOTOGRAPHY

ROLAND J. FRODIGH
US ARMY NATICK LABORATORIES
NATICK, MASSACHUSETTS

Information on seasonal environmental change is of substantial military importance since equipment design criteria, logistics, and basic survival requirements are all affected by the variables of seasonality. This paper describes a program in which photographic time-lapse techniques were used to portray landscapes in a typical mid-latitude region, New England (Fig. 1), from the same site at different seasons. To show the full impact of seasonal variation the identical field-of-view was repeated. All landscapes were recorded in color.

Photography, except in the specialized field of aerial photography, has played a comparatively minor role in geographic research. One purpose of this paper is to show the potential of the camera as a research tool for studying the natural environment. Photographic information when complemented by cartographic and narrative descriptions provides the equipment designer, the tactician, the logistician, and other users with a comprehensive picture of the factors relating to seasonality. Many phenomena, as Moncrieff (1) has written, can be ".... captured on film as part of the scientific process." In the present study, phenomena associated with the march of the seasons have been captured; namely, the successive changes in vegetation color and density, visibility, trafficability, and drainage that are of profound concern in camouflage, other forms of concealment, and in the conduct of military operations.

## Locus of Study and Methods

The Natick Laboratories in Massachusetts provided an excellent location from which to conduct a regional study in an area noted for its marked seasonality. Forty-one New England landscapes were selected for analysis, representing four major physiographic subdivisions: the coastal lowland, the uplands, the interior lowlands, and the mountains. Within each sub-region scenes were recorded illustrating typical terrain features, associated vegetation types and local drainage characteristics. Four-season coverage was recorded at all sites, with a fifth seasonal phase photographed during the early spring at 26 locations within 100 miles of the Natick Laboratories. This additional period was included to portray that part of the year when vegetation is dormant and snow cover is absent (Fig. 2). All landscapes were recorded in color, with the early spring, summer, and winter periods also photographed in black and white. Color is essential to any illustrated study of seasonality.*

The intrinsic value of this study lies in the visual definition of seasonal change which time-lapse photography objectively documents and makes available for analysis and interpretation. When the photographic record is associated with pertinent geographic facts, the usefulness of the study is greatly enhanced. This is demonstrated in Figures 3 and 4, which illustrate a recommended arrangement for presenting combined photographic, cartographic and narrative descriptions in a format designed to give to the reader a comprehensive picture of factors relating to seasonality.

## Field Equipment

The following equipment was used in the field for recording photographic, meteorological, and visibility information:

Three cameras were selected to give broadest possible photographic coverage: (1) a 16mm motion picture camera recorded environmental conditions in color with maximum realism, particularly in scenes where the action of wind or water were apparent. This equipment was also used for photographing random meteorological occurrences, including thunderstorm activity, blizzards, and coastal gale conditions. (2) A 35mm camera was used for producing color transparencies for projection and color reproduction. (3) A 4 x 5 inch camera was used to expose black and white film, providing negatives for making enlargements and for offset reproduction.

Wet and dry bulb temperatures were recorded with a sling psychrometer, and wind speeds were measured with a hand anemometer. Wind direction and camera azimuth were determined with a magnetic compass. Visibility measurements were made in forested areas with a modified Secchi disk (2), an extinction device (target) mounted with its base five feet above ground level, and observed from a standing position.

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* Although it is only possible to provide black and white prints for this paper, the color photography is available at these Laboratories. Monochrome reproduction, of course, does not reveal marked vegetation color changes important to an appraisal of camouflage requirements.

## Field Techniques

After selecting the point from which to photograph a particular landscape, the tripod was firmly set to provide a rigid base for each camera. Nearly all pictures were taken in bright sunlight during the high sun period of the day (1000-1500 hours), in order to insure daylight color temperatures closely equivalent to the color balance of the film.

Movie coverage was recorded in most cases through a 17mm wide angle lens. Ten feet of film was exposed for each sequence at sound speed (24 frames/second). Generally, an additional ten feet of film was shot at one stop above and one stop below the aperture indicated by the exposure meter, providing three exposures from which to select one most closely approximating natural coloration. A film "clip" (two or three frames) cut from footage exposed on the first visit to each site was used as a reference guide for aligning the camera on subsequent visits, assuring smooth transition of time-lapse sequences in the edited film. The 35mm camera was used in a similar manner. Correct exposure as indicated by the meter was bracketed and additional shots made to include the best possible exposure. One of the rejected transparencies served as a guide in framing the identical scene on repeat visits. A small hand viewer was found helpful for viewing both the 16mm film clip and the 35mm slide when adjusting the cameras in the field for proper framing. Effects of fogging on internal lens elements were noticeable on some winter exposures, a problem which was corrected by acclimatizing the camera for longer periods before use. Of the three cameras, the 4 x 5 Speed Graphic proved to be the best suited for precise time-lapse registration. With a contact print made from the negative exposed on the first visit, the author framed each subsequent seasonal exposure on the ground-glass back of the camera, matching the two images. A medium yellow filter was normally used with this equipment. 35mm and 16mm coverage was recorded in color for all seasons. Black and white photographs were not made of the late spring and early fall periods because of slight differences apparent in monochrome between these seasons and the summer period.

Extensive field notes were taken at each site, including information for locating the camera position on return visits. Spot locations were identified by stakes, cairns, or individual rocks. When such markers were hidden under deep snow, it was relatively easy to "zero-in" on the exact spot by referring to the black and white print, adjusting the camera position until the relative position of objects on the 4 x 5 inch ground-glass back of the camera matched those on the 4 x 5 inch contact print. In selecting lowland sites, care was taken to avoid camera positions which are subject to seasonal flooding.

## Seasonal Definitions

In this paper seasons are defined according to landscape appearance, a criterion not necessarily coincident with "calendar" seasons. For example, a landscape photographed on Cape Cod on 1 October, after the autumnal equinox (21 September), would be recorded as a summer scene because summer appearances prevail. Conversely, a landscape photographed on 15 September in the White Mountains of New Hampshire would be designated as a fall scene. Thus the term "season" as used here is a definition based on visual identification. Length of seasons and periods of occurrence within four subregions are shown graphically in Figure 2.

A. Early spring: This period represents that part of the spring season, varying from one to three months in length, when vegetation is dormant and snow-cover is absent. Major differences between early spring and late fall are found in contrasting ground surface conditions. Tall grass, erect in the late fall, becomes matted and bent by winter snows, and low water levels of late fall contrast with the high water of early spring.

B. Late spring: Everywhere in New England late spring begins well after the vernal equinox (21 March). It is a period of new vegetation growth, terminating between late May and mid-June when full leaf growth is attained. Coastal locations experience a lag of two to three weeks in the start of this season compared with interior areas.

C. Summer: The summer season extends from late May through early October, varying in length from 12 to 16 weeks, and is a period when vegetation is green and in full leaf.

D. Early fall: Coloration changes in deciduous vegetation mark the beginning of fall. This season comes first to the mountains and last to coastal areas, where ocean waters have a moderating influence on the climate. The early fall period lasts from four to six weeks and ends when nearly all leaves have fallen.

E. Late fall: This part of the fall is similar to the early spring season with the exception of conditions noted under "A" above.

F. Winter: In this study, winter is treated as the time between late fall and early spring when there is snow-cover on the ground. The average length of the winter season varies from one month or less on Cape Cod and the offshore islands, to more than four months in northern and interior New England.

## Regional Geography

Time-lapse photographic sequences of seasonal contrasts, however revealing, should be supported with information not recorded or only partially recorded by the camera, yet essential to an understanding of regional climatic and geographic controls. Among these are seasonal distributions of temperature and precipitation, period of occurrence and length of seasons, duration of snow-cover, and data relative to terrain, hydrography, vegetation and visibility. The following sections on climate and topography represent descriptive regional geographic information closely related to the study of seasonality. References are made to specific facts in the narrative which are reflected in the photography, some of which necessarily pertain to color contrasts not apparent in the black and white reproductions.

A. Climate: New England is located in the middle latitudes between 41 and 47 degrees north, and although no part of the region lies more than 175 miles from the Atlantic Ocean, its climate is predominantly continental under the influence of prevailing westerly wind flow. Cold air masses of polar origin, and moist tropical air masses from the south meet over the North American continent, creating cyclonic storms which in their normal west to east movement significantly affect New England weather. Influence of the ocean is felt when moisture-laden air is carried on-shore by counter-clockwise circulation around "lows" passing over or close to New England, a condition which spawns blizzards (Northeasters) during the winter months. Coastal snow accumulation illustrated in Figure 5 was the result of a winter storm of this type.

(1) Temperature: "Six degrees of latitude between northernmost and southernmost New England, moderate differences in altitude, and proximity of the Atlantic Ocean, combine to produce wide differences in temperature."(3) These variations are reflected in the duration and period of occurrence of each season, and in the duration of snow cover shown in Figure 2. Also illustrated in this figure is the seasonal "lag" experienced along the coast, where the summer period occurs almost entirely after the high sun of the summer solstice (21 June).

(2) Precipitation: A relatively even distribution of precipitation throughout the year is characteristic of New England. Average annual precipitation varies from approximately 30 inches in the Champlain Valley (Fig. 7) to more than 50 inches in the mountains. Brooks (4) writes: "The heavy storms of winter, the storms and showers of spring, the summer thunderstorms and occasional general storms, and the autumn rains of tropical or mid-latitude origin provide a fairly uniform seasonal distribution for all New England." The number of days on which snowfall occurs varies from less than 30 to more than 120. Snow-cover during the colder months is normally continuous in the mountains (Fig. 8) and in the interior north, whereas warm spells in southern and coastal areas tend to make snow-cover intermittent.

Periods of drought are not uncommon to New England. Extended dry periods create serious fire hazards and alter landscape coloration, particularly during the late summer and fall. These seasons as portrayed in Figure 4 show such low water levels and arid conditions. Dominant brown coloration of the fall scene, vividly evident in the color photography, attests to the effects of prolonged drought, accentuated by normal seasonal color transformation in deciduous vegetation. Conversely, flood control dams have been constructed by the Corps of Engineers along many rivers to control and absorb the impact of unusual runoff, often associated with heavy spring or late winter rainfall and rapid thawing of snow cover. Normal early spring flooding is clearly evident in Figure 4. The lake-like appearance of such inundated lowlands is contrasted with the turbulent flow of upland and mountain streams (Fig. 6). Tropical hurricanes, occuring in the late summer and early fall represent potential flood threats in respect to heavy precipitation as well as to abnormally high tides along the coast. Coastal gale conditions, the result of a hurricane passing east of New England, has been recorded for this study on movie film.

B. Topography: The surface geology of New England is described by Wright (5): "Much of New England is a country of ancient, worn-down mountains, a land of extremely complex rock structure. The ceaseless forces of erosion have etched out a pattern of valleys below the general levels to which the mountains were reduced far back in geological times, and the complexity of relief reflects the complexity of the underlying rocks. The invasions and retreats of the continental ice sheets did much to accentuate the diversified quality of the surface." Landscapes recorded for this study illustrate the diversity of the New England topography. Slow flowing, low gradient rivers meandering along broad floodplains (Fig. 4) contrast with high mountain and upland streams (Fig. 6), draining narrow steep-gradient mountain and upland streams walled valleys. Precipitous, rocky slopes are contrasted with wide lowland valleys.

## Conclusions

The potential for quantitative analysis inherent in vertical aerial photography is lacking in horizontal surface photography. This, however, should not detract from the value of the latter as a useful tool in environmental research. Photography recorded from the viewpoint of the ground observer complements aerial coverage, and contributes to a more comprehensive regional analysis of the natural environment.

Photographic time-lapse sequences of New England landscapes reveal that the magnitude of seasonal change is not fully realized, even by residents around whom such changes repeatedly take place, year after year. This would undoubtedly be true wherever the transition from one season to the next is gradual.

Methods described in this paper could be applied to a wide range of climatic types, among which the tropical savanna is suggested as an example. The seasonal regime of the savanna, unlike that of New England, is controlled by great differences in precipitation, with only a slight annual temperature range. A wet season, marked by predominant green coloration, mud, widespread inundation, swollen streams, and clouds of insects, contrasts with desert-like conditions prevalent during the dry season, a period marked by flint-hard ground, dried-up stream beds, extensive brown grasslands, frequent fires, and dust storms. The military implications here are strikingly apparent. Application of time-lapse photographic techniques would reveal much about such a climate, illustrating drastic changes which occur almost over night.

## References

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3. Church, P. E., A Geographical Study of New England Temperatures, The Geographical Review, April 1936.

4. Brooks, C. F., The Rainfall of New England, New England Water Works Association, Vol 54, March 1930

5. Wright, J. K., Regions and Landscapes in New England, New England Prospects, Spec. Pub. No. 16, American Geographical Society, New York, 1933.

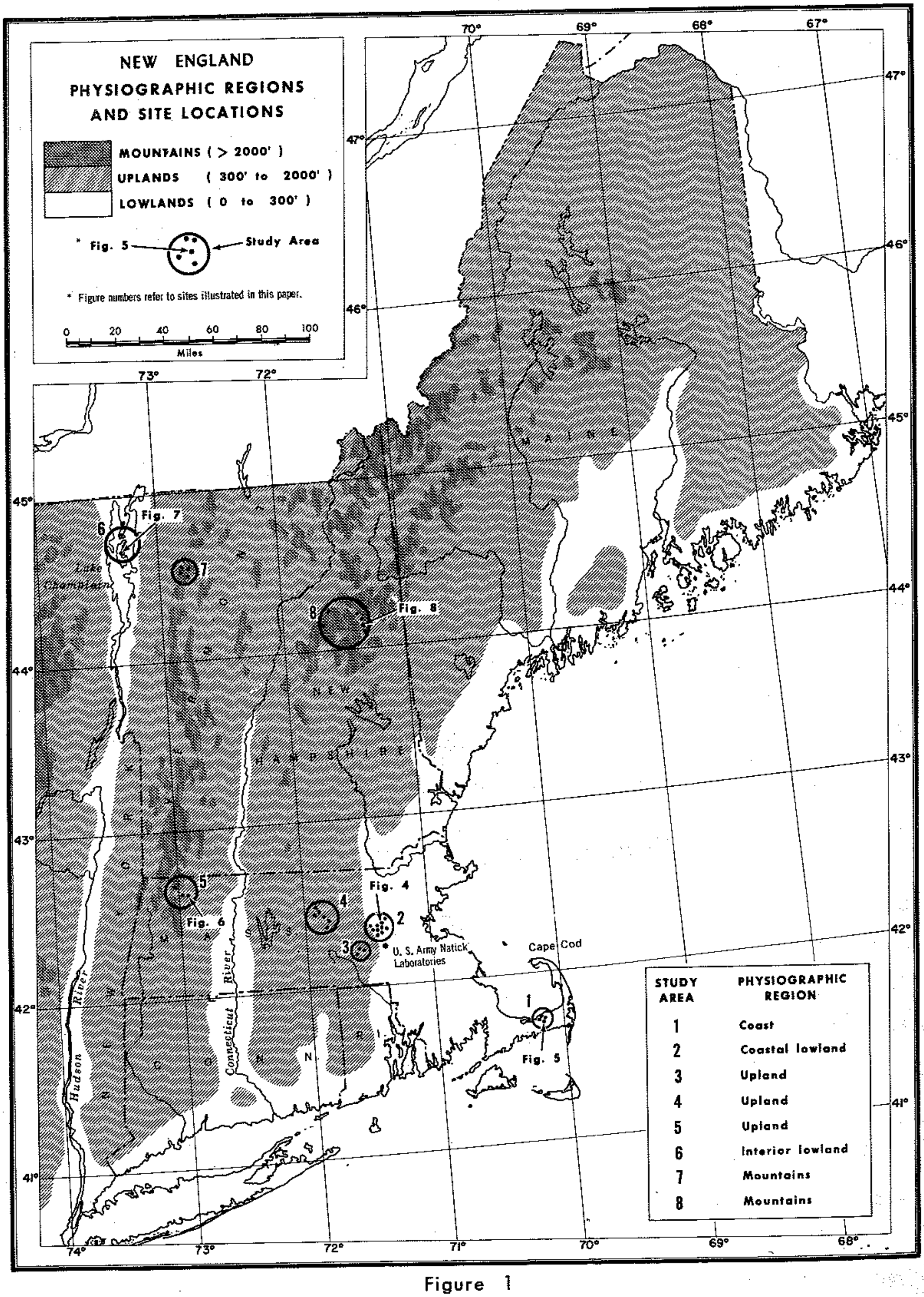
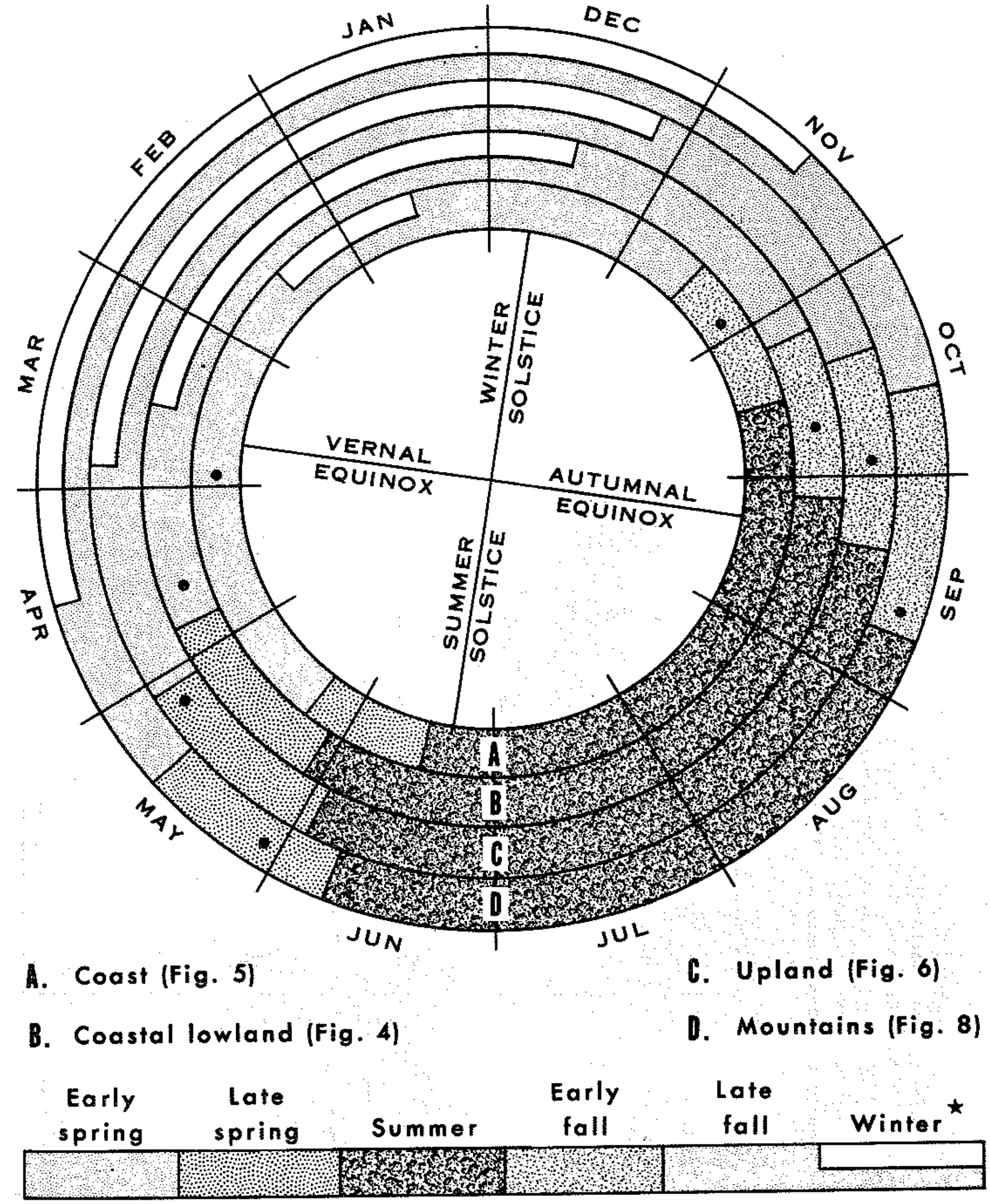

NEW ENGLAND
PHYSIOGRAPHIC REGIONS
AND SITE LOCATIONS
MOUNTAINS ( > 2000' )
UPLANDS ( 300' to 2000' )
LOWLANDS ( 0 to 300' )
* Fig. 5
Study Area
* Figure numbers refer to sites illustrated in this paper.
0 20 40 60 80 100
Miles
Lake Champlain
Hudson River
Connecticut River
U. S. Army Natick Laboratories
Cape Cod
Fig. 4
Fig. 5
Fig. 6
Fig. 7
Fig. 8
STUDY AREA
PHYSIOGRAPHIC REGION
1 Coast
2 Coastal lowland
3 Upland
4 Upland
5 Upland
6 Interior lowland
7 Mountains
8 Mountains

Figure 1




• Mean dates of last killing frost in the spring and first killing frost in the fall.

*Mean number of weeks with snow-cover is indicated by length of the white bands. Snow-cover is normally continuous during the colder months in northern sections and in the mountains, and is normally intermittent along the coast and in southern areas.

Fig. 2: Mean duration and length of seasons in four New England sub-regions.

**LOCATION:** Wayland, Mass. Lat. 42° 23' 59" N., Long. 70° 10' 51" W. Elevation: 120'. Physiographic classification: Sudbury River floodplain, coastal lowland. Local relief: 100'. River gradient: 6"/mile. Climatic classification (Köppen): Dfa. Camera azimuth: 290°.

**AREA DESCRIPTION:** The Sudbury River is typical of many meandering, low gradient stream courses draining the coastal lowland belt of eastern Massachusetts. For ten miles in the area photographed, the floodplain averages six-tenths of a mile in width, varying from 250' to slightly more than one mile. Average stream width is approximately 175'. Vegetation on the valley floor consists of marsh grass, duckweed and other hydrophytic plants. Higher ground and hills are forested, with red maple and oak at lower elevations, interspersed with white pine. Oak, maple, ash and spotty stands of white pine are dominant at higher levels. River water is not potable because of pollution. Relatively small increases in water level (12 to 18 inches) cause widespread inundation. From mid-May to mid- October, wooded areas provide excellent cover.

### EARLY SPRING

J F M A M J J A S O N D

Date: 1 Apr. 1964 Hour: 1515
Temperature: 42° Dew point: 13°
Relative humidity: 30%
Wind: Northwest - 15 MPH
Sky-cover: 2/10 cumulus
Notes: Normal early spring inundation evident. Stream channel difficult to identify. Current noticeable only in narrows.
Mean visibility: 160' (forest)

### SUMMER

J F M A M J J A S O N D

Date: 9 Aug. 1963 Hour: 1430
Temperature: 85° Dew Point: 62°
Relative humidity: 47%
Wind: Southwest - 3 MPH
Sky-cover: None
Notes: Severe drought conditions prevalent, extending into fall. Normal low water for the season. Slight current evident, with algae forming on stream surface. Cover afforded by marsh grass
Mean visibility: 40' (forest)

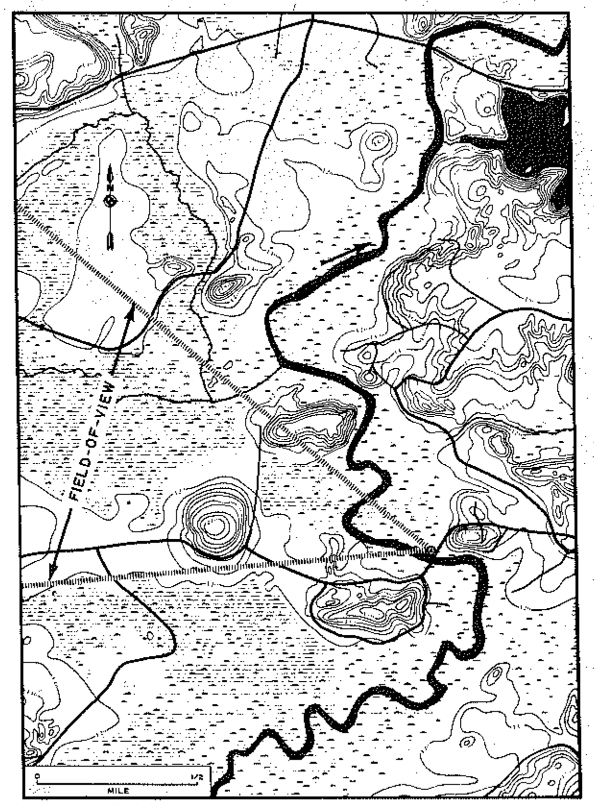



Figure 3

### EARLY FALL

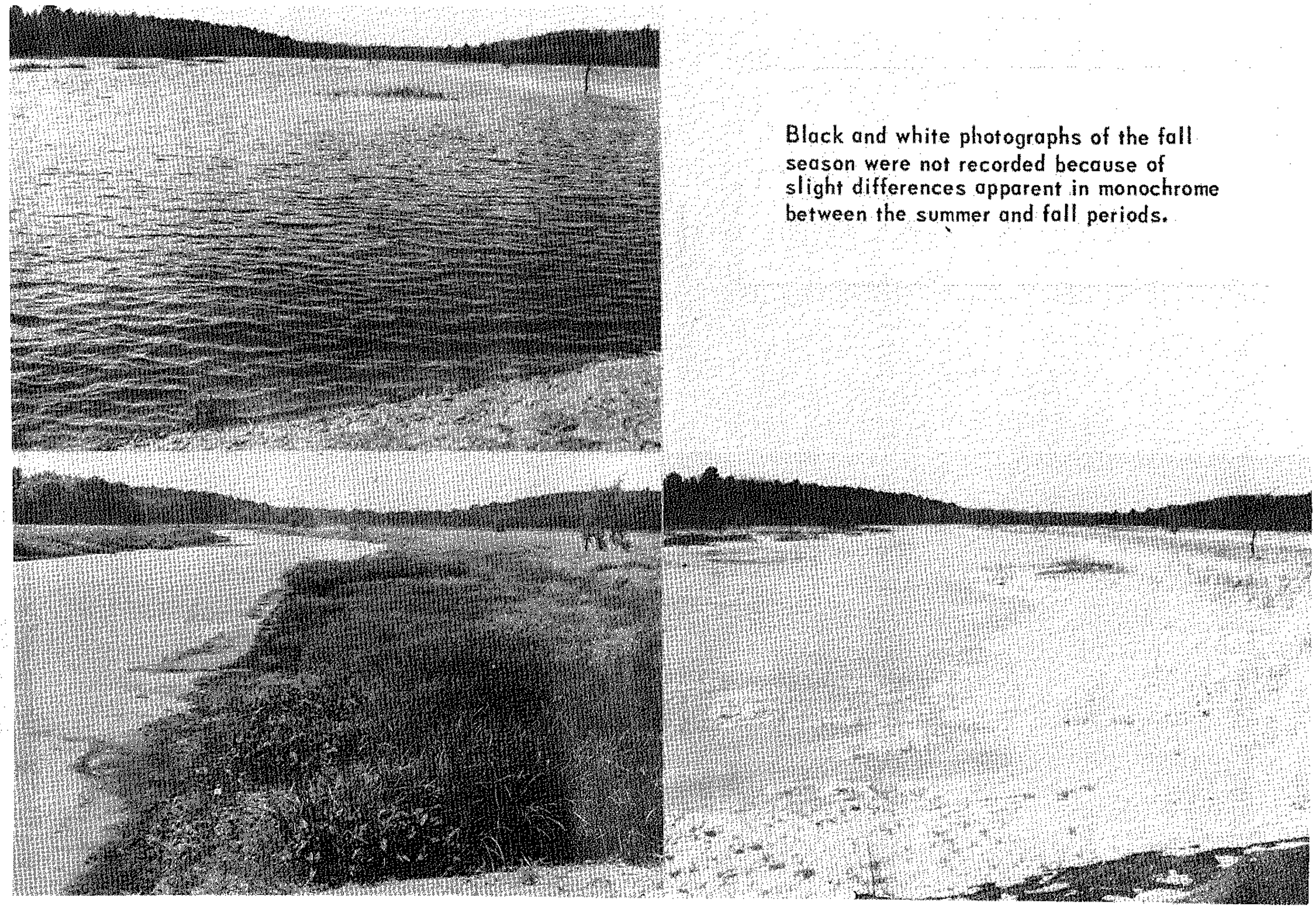
J F M A M J J A S O N D

Date: 16 Oct. 1963 Hour: 1445
Temperature: 77° Dew point: 43°
Relative humidity: 30%
Wind: West - 5 MPH
Sky-cover: 1/10 cirrus
Notes: Severe drought conditions prevalent, with serious fire potential. Cover on floodplain provided by marsh grass (2 to 3 feet high).

### WINTER

J F M A M J J A S O N D

Date: 8 Jan. 1964 Hour: 1440
Temperature: 38° Dew point: 19°
Relative humidity: 46%
Wind: Northwest - 2 MPH
Sky-cover: None
Snow depth: 6 inches
Notes: River is completely ice covered. Floodplain is easily traversed on foot. Best cover is in coniferous stands



Black and white photographs of the fall season were not recorded because of slight differences apparent in monochrome between the summer and fall periods.

Figure 4

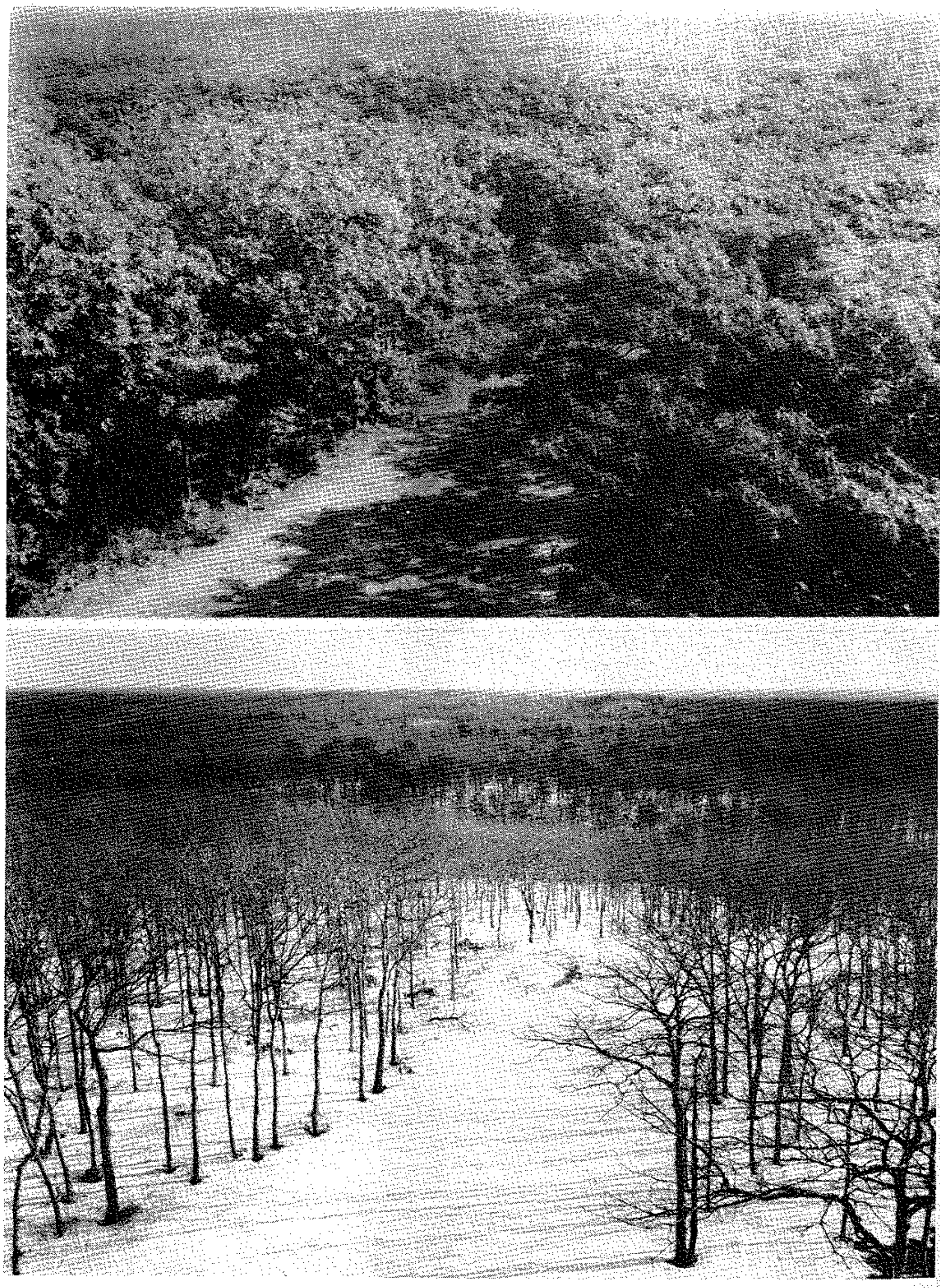


**Fig. 5: Summer and winter seasons, coastal lowland region (Cape Cod), Dennis, Massachusetts.**

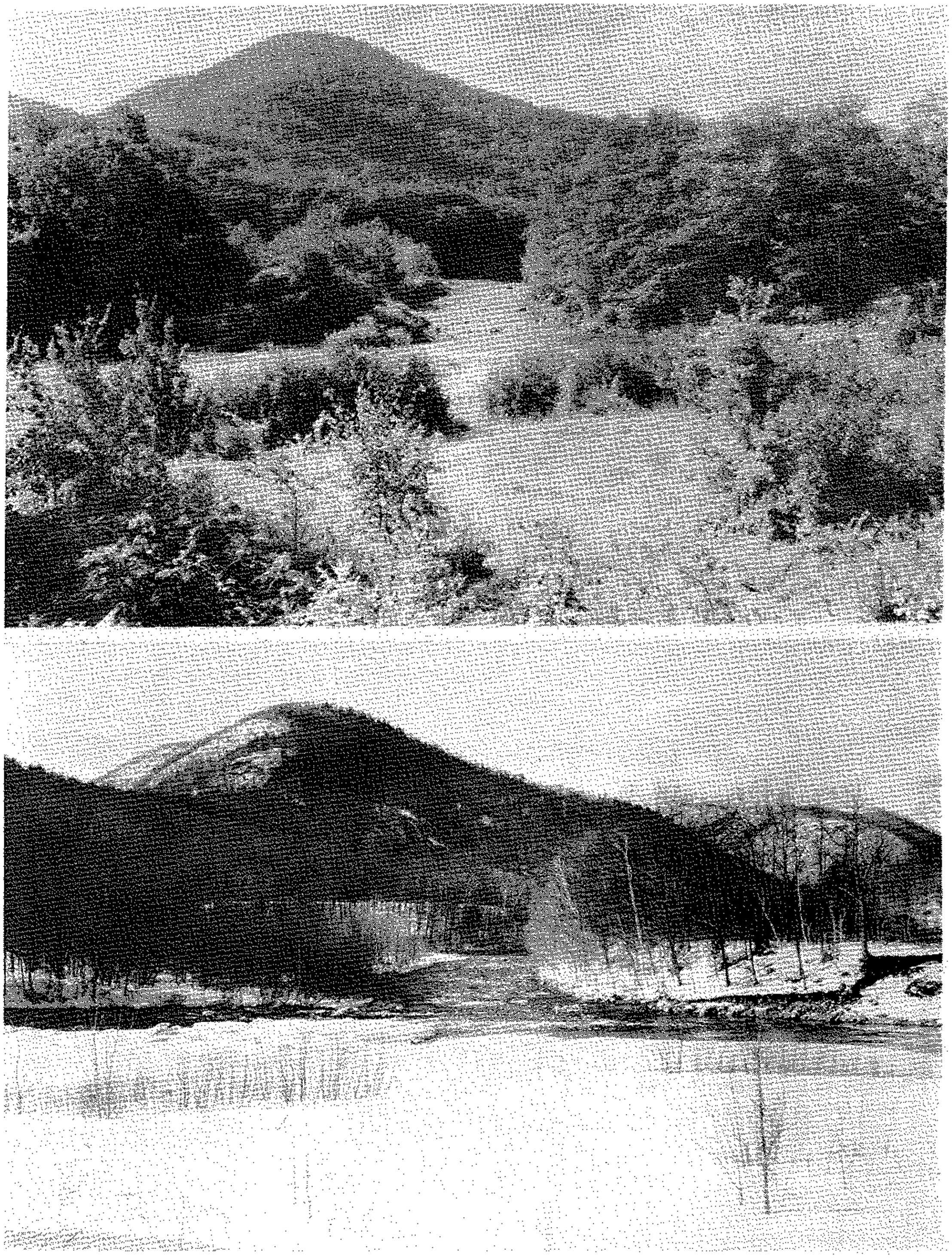


Fig. 6: Summer and winter seasons, upland region (confluence of the Cold and Deerfield Rivers), Savoy, Massachusetts.

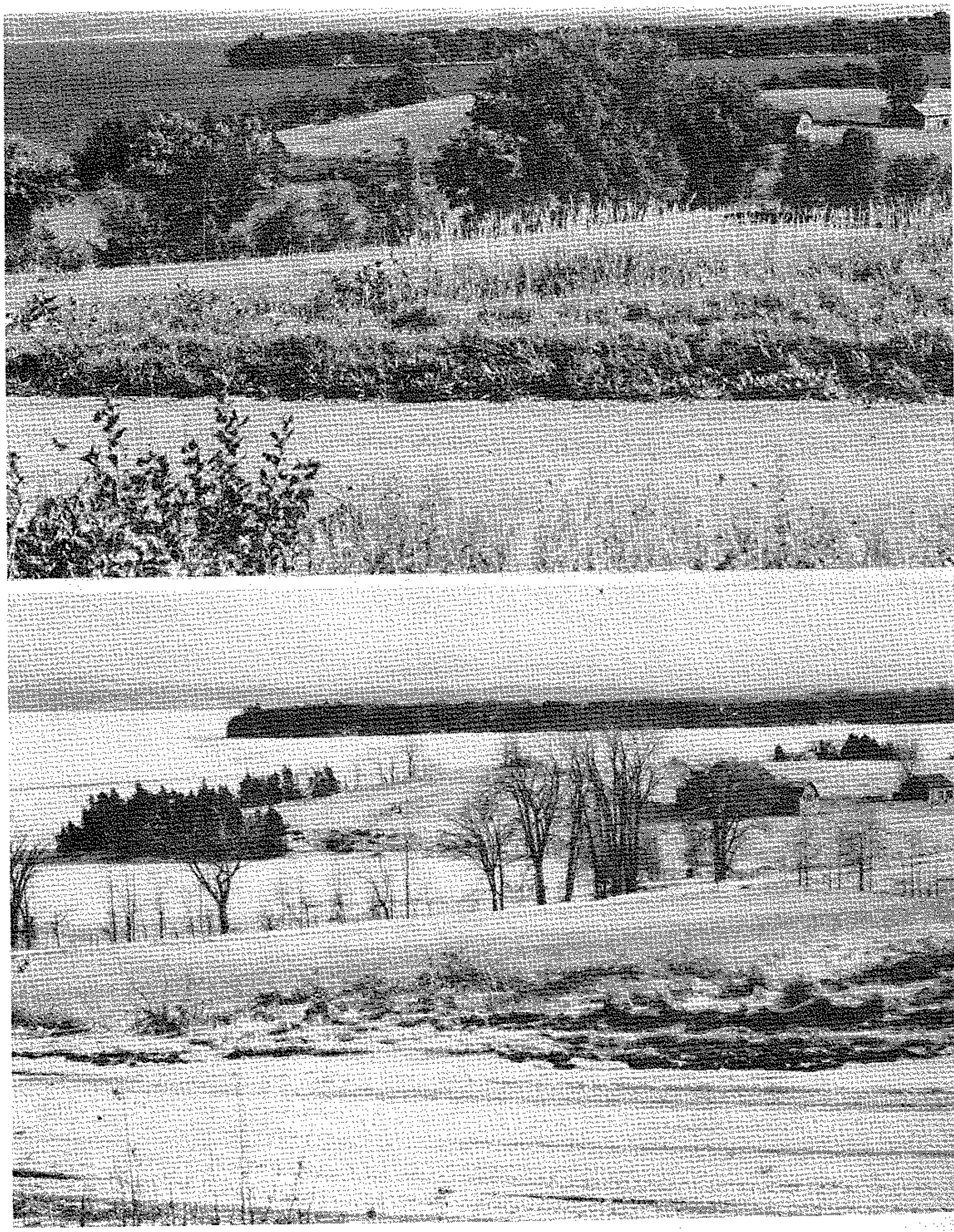


Fig. 7: Summer and winter seasons, interior lowland region (Champlain Valley), Grand Isle, Vermont.

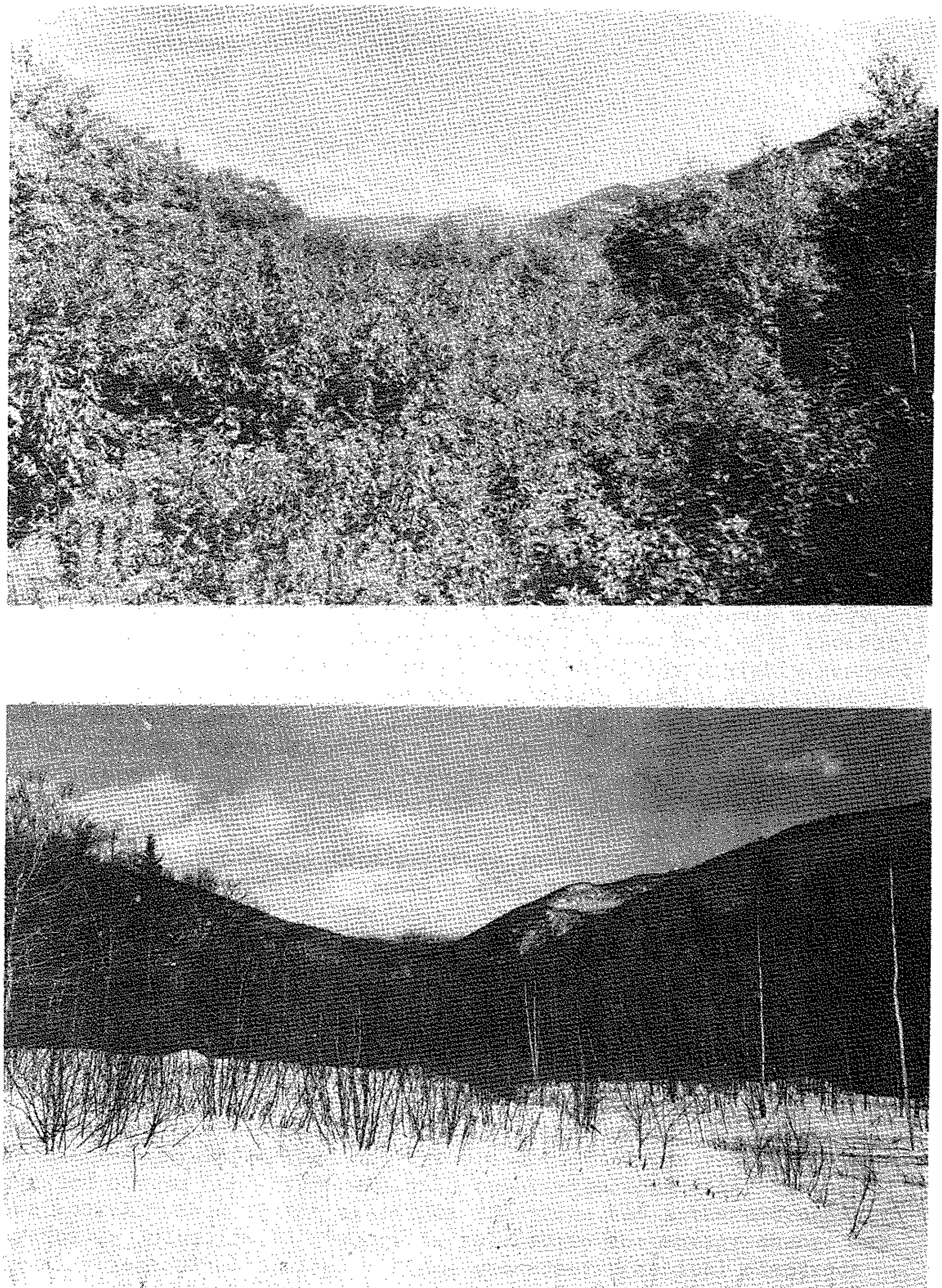


**Fig. 8: Summer and winter seasons, White Mountains (Crawford Notch), New Hampshire.**